A New Spectrometer for Tidbinbilla

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1. Executive summary

This is a proposal to acquire a new spectrometer for Tidbinbilla in time for the winter 2007 season to take advantage of a recent upgrade to the 12mm system which provides dual polarisation with an instantaneous bandwidth of 600 MHz.

The existing correlator at Tidbinbilla will only handle a maximum of two 64 MHz IFs so in order to take advantage of the new front-end and maximise the science output, a new spectrometer is required. Two possible spectrometers are considered: one using the TasPGA hardware being developed at the University of Tasmania, the other based on the ATNF pulsar Digital Filter Bank/CABB.

The 70m remains the most sensitive antenna in the southern hemisphere at 12mm. Even after the current 12mm upgrade at Parkes, the 70m will be ~3.5 times more sensitive and, with a dual-beam system, will be ~24 times more time efficient than Parkes.

ATUC are asked to provide an opinion on the value to users of a new spectrometer and to also provide advice on whether a TasPGA or ATNF system is preferred.

2. Science Case

A detailed science case is provided separately, however the science that could be achieved with the proposed new spectrometer is briefly highlighted here.

A new spectrometer would allow the following science to be pursued:

- Water megamaser surveys and monitoring. Such observations require instantaneous bandwidths of 400 MHz or more to search for the systemic and high velocity lines.
- multi-transition observations for star formation studies. For example, the (1,1), (2,2), (3,3) and (4,4) ammonia transitions could all be observed simultaneously rather than in three separate observations. Also by observing the entire band, many lesser-known transitions could be observed at the same time.
- High redshift molecules. Again, large bandwidths (500 MHz or more) and high sensitivity is required.

Neither megamaser nor high z molecule observations are practical with the existing correlator which would be at least~7 times slower.

The two spectrometers discussed here could also be configured for pulsar observations in the same way as the ATNF pulsar DFB destined for Parkes.

3. Technical details

3.1. Receiver and down-conversion upgrades

Recently ATNF funded an upgrade to the 12mm downconversion chain from single-polarisation to a dual-polarisation capability, providing a √2 improvement in sensitivity in three fixed 600 MHz sub-bands of the full 18-26 GHz range.

Currently JPL are financing a further upgrade to allow simultaneous down-conversion of the off-axis beam. This will permit on and off-source spectra to be obtained at the same time and thus provide another improvement of √2 in sensitivity for pointed observations. The upgrade will also permit observations with instantaneous bandwidth of 600 MHz and is expected to be installed by September 2007.

JPL are also planning an upgrade to permit instantaneous bandwidths of 1 GHz or more for all three 70m antennas. Plans for this upgrade are in an early stage and final specifications are unavailable.

Note that even after its 12mm upgrade, Parkes will be a factor of ~3.5 less sensitive than the 70m and, given that Parkes does not have a dual-beam capability, will be a factor of ~(3.5^2)x2 = 24 times slower in integration time for pointed observations. Thus the usual 300 h per year of 70m time is equivalent to nearly 10 months at Parkes for pointed observations.

3.2. Spectrometer upgrades

Currently Tidbinbilla is equipped with a Parkes Multibeam correlator block that uses an ATNF DAS as a sampler. The maximum bandwidth this system is capable of is two 64 MHz bands and this is clearly the limiting factor in making the most of the current system as well as funded and possible future front-end upgrades. For example, the current correlator requires three steps across the band to cover the (1,1), (2,2), (3,3) and (4,4) ammonia transitions and at least seven steps to cover all maser complexes in a megamaser galaxy with an accretion disk. Given that 70m antenna time is the limiting factor at Tidbinbilla, this correlator in not well matched to the current system let alone to those in the pipeline.

FGPA-based correlators are currently being developed at the University of Tasmania with the TasPGA system and at ATNF with the CABB system. Both are considered here as possible upgrade paths.

3.2.1. Specifications

Both spectrometers would be capable of the following

- 2 x 600 MHz IFs at 8192 chans each
- 2 x 600 MHz IFs divided in up to 8 sub-bands, each with
    - 16 MHz bandwidth and 1024 channels, or
    - 32 MHz bandwidth and 2048 channels

As mentioned above, they could also be configured for pulsar observations. The maximum bandwidth that the TasPGA system could handle would be 2 x 650 MHz while the ATNF system would take 2 x 1 GHz IFs.

Both machines could also be configured for sampling and formatting of wide-band data for eVLBI that could be correlated with other LBA data at Swinburne. Currently Tidbinbilla is limited to data rates of 256 Mbps but the new hardware could provide 2 x 512 Mbps data streams.

3.3. Comparison of spectrometers.

3.3.1. Cost and Delivery time

Both spectrometers are similar in cost. The TasPGA system would cost $26,000 while the ATNF system would cost $35,000 in hardware. The Labour costs are additional, are linked to the delivery time and discussed below.

A delivery date of April 2007, in time for the next winter season would be a challenge to both U. Tas. And ATNF.

For the TasPGA system, the majority of the work would be carried out at the University. However, if they are to meet the deadline, assistance from ATNF would be required in two areas. Firstly, to help optimise the performance of their FPGA chips. For example ATNF have already developed the digital filtering techniques necessary to process wide-band data through a single FPGA while this is still being developed with TasPGA. ATNF engineering time would therefore be required to assist with this. ATNF resources would also be called upon to assist in the production of software to communicate with the correlator from the observing software and to convert the spectrometer output to FITS format for ASAP.

For the ATNF system, the labour cost and time to produce is difficult to estimate at this stage. It depends on other plans. For example, a new set of PCBs needs populating to carry on with CABB testing. So far the only populated CABB Signal Processing PCB will go to Parkes in the Pulsar DFB in November. When the new PCBs for CABB are populated, an extra one could be prepared for Tidbinbilla and this may not be a significant added burden. The main hardware components could be ready by the end of this year. An ATNF system would have almost the same software interface as the existing correlator at Tidbinbilla, making integration and testing relatively straight-forward. Also, by the time of delivery at Tidbinbilla, it's twin, the Pulsar DFB, will have been tried and tested. It seems likely that this approach will require less engineering resources at ATNF than the U. Tas system.

In both cases, an April 2007 deadline would be tight but either could be available by mid 2007 which would allow at least half of the winter time to be used.

3.3.2. Support

As this spectrometer would be a National Facility instrument, support is an important aspect.

For the TasPGA system, the University of Tasmania would help with installation and commissioning, software to control and configure the correlator, and tuition on using and programming the system. Similar equipment is under development for use at Mt Pleasant Observatory, so improvements/updates would be shared. However the limited resources at U. Tas. means that the instrument may not be as well supported as a CABB-based spectrometer.

ATNF would be able to provide the same level of support as they do for their other instruments.

3.3.3. Strategic Considerations

From the perspective of the user, it may seem that a CABB-based system is the obvious direction to take. The hardware development process is more mature and the level of support is likely to be better.

However, ATUC may also wish to consider that supporting hardware development at the universities, and having some diversity in FPGA development is important and healthy. In which case a TasPGA system may be preferable.

4. Questions for ATUC

A strong endorsement is required from ATUC if a new spectrometer is to be obtained.

1. Do ATUC endorse the proposal that ATNF acquire a new spectrometer for Tidbinbilla to take advantage of the new front-end system and that it be available for the winter 2007 season?
2. If so, will ATUC provide advice on whether a CABB or TasPGA-based system is preferred?